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ACCIDENT EXPERIENCE
IRON-ORE MINES - LAKE SUPERIOR DISTRICT
1940-43

BY

FRANK E. CASH AND REUBEN D. LARSEN

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ACCIDENT EXPERIENCE
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By Frank E. Cash[2] and Reuben D. Larsen[3]

INTRODUCTION

The iron-ore ranges in the Lake Superior district are the Marquette in Michigan, Menominee and Gogebic in Michigan and Wisconsin, and the Vermilion, Mesabi, and Cuyuna in Minnesota. These ranges produce about 85 percent of the iron ore mined in the United States. Accident experience in connection with this production is better than that of the regions producing the remaining 15 percent. Production and shipments vary slightly from year to year but closely approximate each other over a period of years.

During the 4-year period 1940 to 1943, inclusive, 323,667,599 long tons of iron ore was shipped from the Lake Superior district.[4] Michigan and Wisconsin shipped 65,386,608 tons, or 20.2 percent of the total, and employed approximately 15,000 men; Minnesota shipped 258,280,991 tons, or 79.8 percent of the total, and employed approximately 10,000 men. The tons produced per man employed is much greater in Minnesota than in Michigan and Wisconsin owing to the large open-cut production in Minnesota.

ACKNOWLEDGMENTS

This consolidated report was made possible through the cooperation of the operating companies in furnishing their annual accident data for use at the Lake Superior Mining Section, National Safety Council annual meeting, and to them the authors express their appreciation. These data were first compiled and presented in 1941 to cover the 1940 experience.

MINING METHODS

In Minnesota, most of the ore is produced from open-cuts. In Michigan and Wisconsin, the mining methods used, in the order of their relative production, are top slicing, sublevel caving, and open stoping; only a small tonnage of ore is mined from open-cuts.

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[1] The Bureau of Mines will welcome reprinting of this paper, provided the following footnote acknowledgment is used: "Reprinted from Bureau of Mines Information Circular 7321."
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[4] Tonnage figures from Lake Superior Iron Ore Association.

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The average number of operating mines in the region during the 4-year period was 120, of which 64 were open-cut and 56 underground operations. Twenty-five of the underground mines employ the top-slicing method of mining, 16 sublevel caving, and 15 open stoping.

ACCIDENT EXPERIENCE

These accident data were largely taken from those furnished by the operating companies and assembled and published by the Lake Superior Mining Sectio of the National Safety Council.[5] However, they are supplemented, for purpose of comparison, by figures published by the Bureau of Mines in the report of th National Safety Competition and Annual Survey of Metal Mines Accidents.[6] Thi discussion of the data is based entirely on observations and opinions of the authors.

The period from 1940 to 1943 was a one during which increased productio was necessary, and the manpower shortage, although not acute, was definitely liability as regards improving accident experience.

Table 1 gives (by years and totals for all mines) the shipments, man-hou worked, days lost as the result of accidents, fatal and total permanent disability accidents, partial permanent disability accidents, and temporary accidents, with frequency and severity rates, for the 4-year period.

The frequency rate is the number of lost-time accidents per million man-hours worked, and the severity rate is the number of days lost because of accidents per thousand man-hours worked. A lost-time accident is considered to one that causes loss of time beyond the day or shift on which the accident occurred. In calculating severity, temporary disabilities are weighted acc ing to actual calendar days of disability, including holidays and Sundays; whereas, deaths and permanent injuries are weighted according to the United States Bureau of Mines "Scale of Time Losses for Weighting Deaths and Perma Injuries", adopted from the American Standards Association.

TABLE 1. - Accident Data, all mines, 1940-43

Year	Gross tons shipped	Man-hours worked	Days lost account accidents	Fatal	Partial permanent	Temporary	Frequency	Severit
1940	63,948,846	31,217,310	139,303	*17	7	359	12.27	4.46
1941	80,747,859	41,239,423	200,114	25	13	515	13.41	4.85
1942	93,008,726	45,912,672	264,701	34	12	745	17.23	5.76
1943	85,962,168	51,863,102	273,157	*34	25	1,035	21.09	5.27
	323,667,599	170,232,507	877,275	110	57	2,654	16.57	5.15

*Includes 1 total permanent.

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[5] Percy A. Carmichael (1941 and 1942 proceedings) and Reuben D. Larsen (1943 and 1944 proceedings), Lake Superior Mining Section, National Safety Council.

[6] W. W. Adams and others.

Along with the increase in man-hours worked, the frequency rate increased ach year, and the severity rate increased for the first three years but showed slight improvement for 1943. During the 4-year period, there were 108 fataliies, 2 total permanent total-disability accidents, 57 partial-permanent, and ,654 temporary disabling accidents; these are tabulated and discussed as to auses, types of operations, and methods of mining. Of the 110 fatal and total isability accidents, falls and slides of ground were responsible for 49, or 4.5 percent; haulage accidents (belt, truck, and locomotive) were next, with , or 7.3 percent of the fatal accidents. Other causes, in order of number of esulting accidents, were: Explosives, 6; machinery (moving), 5; loading equipent (shovels, scrapers, etc.) 5; persons falling (shafts, raises, chutes, and anks), 5; railroad cars and locomotives (surface), 5; persons falling (slipping nd stumbling), 4; falling material (shafts, chutes, and raises), 4; electrical hocks and burns, 4; suffocation (natural gases), 3; cages and skips (shafts nd raises), 3; handling material, 2; runs of ore and rock (chutes and bins), ; falling material other than ground, 1; drilling equipment, 1; not classified, .

There was one fatal accident for each 2,942,433 tons shipped, one partial ermanent disability for each 5,678,379 tons, and one temporary disability for ach 121,955 tons shipped. For each fatality, there were 0.5 partial-permanent nd 24.1 temporary-disability injuries.

As a means of comparison, table 2 lists the frequency rates for the iron-re mines in the United States, the frequency and severity rates for the metal ines entered in the National Safety Competition, and the iron-ore mines in he Lake Superior district for the years 1940 to 1943, inclusive. The table hows that the Lake Superior district has had better frequency and severity ates each year (except the severity rate in 1942) than either of the other two roups.

TABLE 2. - Comparison of frequency and severity of accidents in iron-ore mines, 1940-43

	Iron-ore mines, United States	Metal-mines entered in National Safety Competition		Iron-ore mines, Lake Superior District	
Year	Frequency	Frequency	Severity	Frequency	Severity
940	19.63	14.47	6.09	12.27	4.46
941	23.08	20.14	6.85	13.41	4.85
942	24.40	20.62	5.55	17.23	5.76
943	24.79	24.21	6.27	21.09	5.27

Table 3 gives the accident data (including totals and combined figures) or the 4-year period, by years, in the Lake Superior District, divided as to ype of operation.

Although all accidents are potentially serious, and their occurrence must e decreased to improve accident experience, once an accident happens, the lost ime, suffering, reduction in production, and expense are largely reflected in everity rather than in frequency.

TABLE 3. - Accident data, by methods, all mines, 1940-43

Type of operation	Man-hours worked	Days lost	Fatal	Partial permanent	Temporary	Frequency	Severity
Miscellaneous development ..	338,574	214	0	0	3	8.86	0.63
General shops	15,141,613	17,646	2	3	77	5.41	1.17
Open-cuts and concentrator plants	60,399,554	276,869	34	23	616	11.14	4.58
Top slicing	38,665,669	199,413	22	13	780	21.08	5.16
Stoping	19,380,944	125,675	17	7	349	19.25	6.48
Sublevel caving	36,306,153	257,458	35	11	829	24.10	7.09
All operations	170,232,507	877.275	110	57	2,654	16.57	5.15

TABLE 4. - Accident disability, 1940-43

Type of operation	Fatal*		Partial permanent*		Temporary	
	Accidents	Days lost	Accidents	Average days lost	Accidents	Average days lost
Miscellaneous development	0	-	0	-	3	71.3
General shops	2	6,000	2	658.3	78	35.4
Open cuts and concentrator plants	34	6,000	23	1,767.4	616	52.3
Top slicing	22	6,000	13	1,197.5	780	66.5
Stoping	17	6,000	8	1,245.0	349	42.9
Sublevel caving	35	6,000	11	1,082.7	828	43.9
All operations	**110	6,000	57	1,393.1	2,654	52.2

* Weighted disabilities.

** Including 2 permanent total disabilities.

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For comparison in this paper since the accidents have occurred, severity is used for the weighting figure.

Under "type operations," "miscellaneous development" is all underground work and includes prospecting, extensive rock drifting, and shaft sinking and raising. "General shops" are those doing the general repair work for a group of mines. In most instances, the shop experience is included with the individual mine. "Open cuts and concentrator plants" cover the open-cut mines and their concentrating plants, whether the plants are locally or centrally located and operated. "Top slicing," "stoping," and "sublevel caving" are the various methods of mining used underground.

As shown, the most hazardous operation is sublevel caving, in which both frequency and severity rates are higher than in other operations. Although limited in extent, "miscellaneous (underground) development" is shown as having the best accident experience. The frequency and severity rates for all operations in the region for the 4 years are favorable when compared with other iron-ore and metal-mine operations in this country.

In table 4, the accidents are listed under the various type of operations, and the average length of disability per accident is shown for each type of operation.

All fatalities and the partial permanent disabilities are weighted, the former at 6,000 days, and the latter varies with the extent of the disability.

There are two noticeable figures. One is found under "open-cut and concentrator plants," where operations are virtually all mechanical and the average weighted days lost under partial permanent disabilities is two to three times as great as in other types of operations. The other is that the average duration of temporary disabilities is greatest in top slicing, which is one of the least hazardous of underground mining methods, and least in sublevel caving, where the hazards, as shown by the 4-year figures, are the greatest.

Table 5 lists fatal, partial-permanent, and temporary disabling accidents by years and causes for all mines.

These accident data were obtained from the 26 operating companies over a period of 4 years. There are differences in company methods of compiling accident data; and although certain local procedures answer the purposes of the individual company, it is often difficult to classify an accident as to cause. A number of the accidents listed as unclassified would probably fall in one of the other classifications, had the descriptions been more definite and complete.

Table 5 gives a complete, detailed picture of accidents and their causes under the various type operations for the 4-year period.

TABLE 5. - Accidents, by years, divided as to causes and types of operation, 1940-43

		Miscellaneous development				General shops				Open-cuts and concentrators				Top slicing				Stoping				Sublevel caving				All operations				Total
		40	41	42	43	40	41	42	43	40	41	42	43	40	41	42	43	40	41	42	43	40	41	42	43	40	41	42	43	
Falls and slides of ground (rock and ore)	F	-	-	-	-	-	-	-	-	1	1	3	2	3	1	5	4	2	-	2	5	4	7	7	2	10	9	17	13	49
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	-	-	1	1	2	0	1	1	4
	T	-	-	-	-	-	-	-	-	-	-	4	8	17	22	62	58	5	12	17	17	4	42	47	63	26	76	130	146	378
Haulage (belt, truck, and locomotive)	F	-	-	-	-	-	-	-	-	-	2	2	1	-	-	-	-	-	-	-	1	-	1	-	1	0	3	2	3	8
	PP	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	1	-	2	-	-	-	2	2	1	0	5
	T	-	-	-	-	-	-	-	-	-	9	18	20	6	6	-	8	2	2	5	10	1	12	1	18	9	29	24	56	118
Explosives	F	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	-	2x	-	1	1	2x	0	1	3	6x
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	1	-	2	-	1	1	2	0	4
	T	-	-	-	-	-	-	-	-	-	-	-	4	2	1	-	3	-	-	-	-	1	-	4	-	3	1	4	7	15
Machinery (moving)	F	-	-	-	-	-	-	1	-	1	1	-	1	-	-	-	-	-	-	-	1	-	-	-	-	1	1	1	2	5
	PP	-	-	-	-	-	1	-	1	-	1	-	1	-	-	1	1	-	1	-	-	-	-	-	-	0	3	1	3	7
	T	-	-	-	-	-	-	2	2	-	-	2	14	-	-	-	13	-	-	-	15	-	8	-	19	2	8	4	63	77
Loading equipment (shovels, scrapers, etc.)	F	-	-	-	-	-	-	-	-	-	1	1	1	-	-	1	-	-	-	-	-	-	1	-	-	0	2	2	1	5
	PP	-	-	-	-	-	-	-	-	1	-	-	1	1	-	-	-	-	-	-	-	-	-	-	2	2	0	0	3	5
	T	-	-	-	-	-	-	-	-	1	-	8	14	-	8	9	1	-	-	-	7	1	5	10	1	2	13	27	23	65
Persons falling (shafts, raises, chutes, and banks).	F	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	-	-	-	1	-	-	2	-	-	0	2	3	0	5
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0
	T	-	-	-	-	-	-	-	-	-	-	6	-	1	-	2	6	4	3	1	14	-	-	11	3	5	3	20	23	51
Railroad cars and locomotives (surface)	F	-	-	-	-	-	-	-	1x	-	1	2	-	-	-	-	-	-	-	-	-	-	-	-	1	0	1	2	2x	5x
	PP	-	-	-	-	-	-	-	-	-	1	-	5	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	5	6
	T	-	-	-	-	-	-	-	-	-	5	-	4	-	-	-	-	1	-	1	-	-	-	-	-	1	5	1	4	11
Persons falling (stumbling and slipping)	F	-	-	-	-	-	-	-	-	-	-	1	3	-	-	-	-	-	-	-	-	-	-	-	-	0	0	1	3	4
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0
	T	-	-	-	-	-	-	-	3	-	13	11	34	3	12	17	34	-	-	5	7	-	12	-	21	3	37	33	99	172
Falling material (shafts, chutes, and raises)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	3	-	-	-	-	-	-	1	-	-	-	1	3	0	0	4
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0	0	1	1
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	6	7	-	-	-	-	1	-	-	6	1	0	6	13	20
Electricity (shock and burns)	F	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	1	-	-	-	-	-	1	0	3	4
	PP	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	0	0	1
	T	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	4	2	-	1	-	-	-	1	4	3	8
Suffocation (natural gases)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	2	-	-	-	2	0	1	3
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0
	T	-	-	-	-	-	-	-	-	-	-	11	-	-	-	-	-	-	-	-	1	-	-	-	-	-	0	11	1	12
Cages and skips (shafts and raises)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	1	-	-	1	2	3
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	-	1	1	-	-	9	1	10
Handling material	F	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	1	-	-	-	1	0	1	0	2
	PP	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	1	1
	T	-	-	-	-	-	-	-	-	-	3	-	11	2	-	24	23	1	1	10	24	4	-	20	30	7	4	54	88	153
Runs of ore and rock (chutes and bins)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	1	-	-	-	-	-	1	-	1	2
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	-	0	0
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	7	-	-	-	4	-	1	-	11	12
Falling material (other than ground)	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	0	1	0	1
	PP	-	-	-	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	1	0	2	3
	T	-	-	-	-	-	-	1	-	-	-	-	14	-	13	-	26	-	-	-	5	-	-	-	17	-	13	1	62	76
Drilling equipment	F	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	0	1
	PP	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	3	-	1	1	-	-	-	-	-	-	1	2	4	7
	T	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	-	3	-	0	4	3	7
Flying objects	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0
	PP	-	-	-	-	-	-	-	-	-	-	2	3	-	1	2	1	-	1	-	-	-	1	-	-	0	3	4	4	11
	T	-	-	-	-	-	-	1	-	-	-	-	11	1	-	-	12	-	-	4	8	-	-	-	27	1	0	5	58	64
Hand tools	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0
	PP	-	-	-	-	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	-	-	-	-	-	0	1	1	2
	T	-	-	-	-	-	1	-	4	-	-	11	7	-	-	-	14	-	-	-	-	-	-	7	-	-	1	18	25	44
Mines fires	F	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0
	T	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	-	5	5
Not classified	F	-	-	-	-	-	-	-	-	2	-	1	-	-	-	-	-	-	-	-	-	-	-	-	-	2	0	1	0	3
	PP	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0	0	0	0	0
	T	0	1	1	1	6	24	14	16	54	80	93	143	87	68	108	98	16	23	77	28	136	127	97	58	299	323	390	344	1,356
Total	F	0	0	0	0	0	0	0	1x	4	6	13	11	3	6	8	5	2	0	4	11	8x	13	8	6	17x	25	34	34	110
	PP	0	0	0	0	0	1	0	2	1	4	4	14	1	4	3	5	2	3	2	0	3	1	3	4	7	13	12	25	57
	T	0	1	1	1	6	25	21	25	57	110	164	285	119	130	228	303	29	42	133	145	148	207	198	276	359	515	745	1,035	2,654
Grand total		0	1	1	1	6	26	22	28	62	120	181	310	123	140	239	313	33	45	139	156	159	221	209	286	383	553	791	1,094	2,821

X - Includes 1 total permanent.
F - Fatal.
PP - Partial permanent.
T - Temporary disability.

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Aside from the "not-classified" accidents, there are 19 listed causes of the accidents. Falls and slides of ground caused the greatest number of fatal and temporary-disabling accidents. Haulage came next as a cause of fatal accidents; but accidents due to persons slipping, stumbling, and falling ranked second in the total number of accidents. Railroad cars and locomotives caused only 22 accidents, but these were very severe and resulted in 5 fatalities (including one permanent total disability) and 6 partial-permanent disabilities. Electricity caused 13 accidents, four of which were fatal and one of which was a partial permanent disability. Flying objects caused 75 accidents, with no fatalities, but resulted in loss of sight of 11 eyes. Mines fires, which are too frequent, caused only 5 temporary disabling injuries.

SUMMARY

On an average, 120 iron mines are operated by 26 companies in the Lake Superior district, which annually produces about 85 percent of the iron ore mined in the United States. Individual open-cut mines produce 20,000 to 20,000,000 tons annually, and the underground mines from 100,000 to 1,000,000 tons a year.

The accidents in the district, although relatively fewer and less severe than in other metal-mining districts, have increased in frequency during each of the four years 1940-43, inclusive, with a similar increase in severity for the first three years but a slight decrease in 1943. This condition has been experienced in practically all of these operations.

"Miscellaneous development," usually considered hazardous work, although covering the relatively small number of 338,574 man-hours, occasioned only 3 lost-time accidents, which resulted in 214 days of disability. The accident rates for the 4 years were frequency, 8,86, and severity, 0.63.

"General shops" covers a total of over 15 million man-hours with 82 accidents, divided as follows: 2 fatal (1 total permanent disability), 3 partial permanent, and 77 temporary disabilities. The frequency rate increased from 1.63 in 1940 to 7.76 in 1943, with a total 4-year rate of 5.41; the severity rate increased from 0.03 in 1940 to 2.26 in 1942 and dropped to 2.03 in 1943 for a total 4-year rate of 1.17.

Under "open cuts and concentrator plants," the hours worked increased each year, with a corresponding increase in the frequency rate each year, an increase in the severity rate for the first three years, and a slight decrease in 1943. During the 4-year period there were 34 fatal, 23 partial-permanent, and 616 temporary disabilities. The frequency rate increased from 6.88 in 1940 to 14.82 in 1943, for a total average rate of 11.14 for 4 years. The severity rate increased from 2:65 in 1940 to 6.03 in 1942 and dropped to 4.59 in 1943 for a 4-year average rate of 4.58.

Under "top slicing," the hours worked increased each year. During the 4-year period there were 22 fatals, 13 partial-permanent, and 780 temporary disabilities. The frequency rate decreased from 16.90 in 1940 to 15.53 in

1941 and increased to 27.46 in 1943 for an average 4-year rate of 21.08. This 4-year average rate is higher than the rate under "stoping" and lower than that for "sublevel caving." The severity rate under "top slicing" increased from 4.76 in 1940 to 5.94 in 1942 and decreased to 4.23 in 1943, for a 4-year average rate of 5.16. This 4-year average severity rate is th lowest of the underground operations.

Under "stoping," over 19-million man-hours were worked during the 4 years, during which 17 fatal, 7 partial-permanent, and 349 temporary injuri occurred. The frequency rate increased from 11.59 in 1940 to 24.91 in 1943 the 4-year average rate was 19.25. The severity rate decreased from 5.56 i 1940 to 1.08 in 1941 and increased to 11.44 in 1943 for a 4-year average ra of 6.48.

Under "sublevel caving," a total of 36,306,153 man-hours was worked, during which 35 fatal, 11 partial-permanent, and 829 temporary disabilities occurred. The frequency rate increased from 18.61 in 1940 to 29.74 in 1943 the 4-year average rate was 24.10. The severity rate increased from 6.93 i 1940 to 9.40 in 1941 and decreased to 5.20 in 1943; the 4-year average rate was 7.09. As shown by the figures, sublevel caving had the highest average frequency and severity rates for the 4-year period.

Over 170 million man-hours were worked in all the operations. The over all frequency rate increased from 12.23 in 1940 to 21.09 in 1943, and the severity rate increased from 4.27 in 1940 to 5.76 in 1942 and decreased to 5.27 in 1943. The 4-year average frequency rate was 16.57, and the sev rate was 5.15.

Most of the mines are highly mechanized and during the past 4 year produced increasing tonnages of iron ore with a minimum of repair and replacement to mechanical equipment. Permanent installations of mechanical and electrical equipment usually are well-guarded.

In most of the underground mines, electric cap lamps are furnished and employees are required to wear hard hats and safety-toe shoes; for certain classes of work, safety goggles are furnished, and wearing is mandato

With the exception of the very small producers, the companies have safety supervisors and safety inspectors. The small companies usually rel on the superintendent to combine safety work with his operating activities.

Most of the companies operating underground mines maintain rescue equipment and train personnel in its use.

Previous to 1940, most of the companies provided first-aid training f their employees, and a number of them had 100 percent employee first-aid training. Since 1940, very little first-aid training has been done in the district.

Most companies have some form of printed or mimeographed operative and safety rules. Most open-cut mines require the wearing of protective shoes or boots in summer, but in severely cold weather some allow their employees to discontinue their use. Protective hats are worn in a few open-cut mines.

A number of companies provide goggles, and some issue the corrective-vision type. A few companies require their use throughout the shift for all employees, but many leave it up to the individual to wear them when necessary or leave it to the supervisory force to require their use for selected types of work.

All underground hauling is done with electric locomotives, a few of which are storage-battery types. Haulage in open-cut mines is by belt, electric and steam locomotives, and most often, trucks. About half of the underground mines have stench-warning systems for emergency use.

Loading in open-cut mines is done largely by electrically operated shovels, with an occasional steam- or gasoline-operated shovel operating in some mines. In the underground mines, virtually all ore is dragged by electrically operated scrapers into chutes or cars.

Open-cut drilling is done largely by gasoline or electrically operated well- or wagon-type drills, with a few gasoline-operated augur-type drills for soft material. In the underground mines, compressed air-operated percussion-type drills are generally used, and virtually all drilling is done wet.

In open-cut mines, blasting is done with dynamite and some "nitramon," which is detonated with electric blasting caps or electric blasting caps and detonating fuse. The explosive in use underground is dynamite with fuse and detonators, except in extremely wet places, shaft sinking, and heavy blasting; a limited amount of blasting is done electrically.

Most of the underground mines have two or more openings and are ventilated mechanically. A few mines have excellent ventilation systems with provision for heating the air in cold weather; others are not so well ventilated.

In general, a determined effort is being made by the mining companies n the Lake Superior district to minimize accidents incurred in mining iron ore. Compared to other metal mines in this country, this district's accident experience is favorable, but, even so, it can and should be improved. Such improvement can be realized by a closer coordination of effort by employees nd management.